Eur. Phys. J. C (2018) 78:918
https://doi.org/10.1140/epjc/s10052-018-6409-5

THE EUROPEAN PHYSICAL JOURNAL C

Regular Article - Theoretical Physics

Non-minimal coupling influence on the deviation from de Sitter cosmological expansion

I. V. Fomin[1,a], **S. V. Chervon**[2,3,b]

[1] Bauman Moscow State Technical University, 2nd Baumanskaya Street, 5, Moscow 105005, Russia
[2] Ulyanovsk State Pedagogical University, Lenin's Square, B. 4/5, Ulyanovsk 432071, Russia
[3] Kazan Federal University, Kremlevskaya Street, 18, Kazan 420008, Russia

Received: 19 March 2018 / Accepted: 23 October 2018 / Published online: 12 November 2018

Abstract We investigate the models of cosmological inflation in generalized scalar–tensor gravity, which we consider as a source of deviation from de Sitter dynamics in the case of GR. Within the framework of the proposed approach, the exact equations of cosmological dynamics and parameters of cosmological perturbations are obtained.

1 Introduction

The inflationary paradigm is currently the main approach to describing the evolution of the early universe avoiding the horizon, flatness and homogeneity problems [1–4]. Also inflation describes the formation of large scale structure of the universe in the context of the origin of primary inhomogeneities and relict gravitational waves [5,6] (for review, see [7,8]). Most of the first inflationary models were based on the Einstein gravity coupled to self-interacting scalar field in Friedmann universe [2–4] while the pioneering work by Starobinsky [1] was related to modified f(R) gravity which arose from quantum one-loop contributions of conformally covariant matter fields.

At the present time, to explain the stage of the accelerated expansion of the universe [9,10] (the construction of dark energy models), the cosmological models of modified f(R) gravity, which differ from Einstein gravity are actively considered [11–16] (for review, see [17]). One of the oldest generalizations of GR, the scalar–tensor gravity (STG), also can describe the early and later inflation [18].

Let us note that both f(R) gravity and STG are conformally related to GR with a scalar field minimally coupled to gravity. The original papers where it was shown are [19] for an arbitrary f(R) and [20] for a more general scalar–tensor case. Such conformal connection of the models with f(R) gravity and GR is considered, for example, in the work [21]. The conformal connection of cosmological models on the basis of STG and GR have been studied for example, in [22]. Therefore, on the basis of the inverse conformal transformation from GR to STG it is possible to find the connection between STG and f(R) gravity. Such conformal connection between f(R) gravity and STG have been considered, for example, in [23,24].

Scalar–tensor gravity theories are important extensions of GR, which can explain both the initial inflationary evolution, as well as the late accelerating expansion of the Universe. The examples of inflationary models on the basis of scalar–tensor gravity theories with the exact solutions were considered in the works [25–31]. Also, in the articles [32,33] the equations of cosmological dynamics for STG were reduced to ones for the Einstein gravity in the case of the Friedman–Robertson–Walker metric by a specific choice of the coupling function and the kinetic function. This makes it easy to translate the solutions obtained for standard GR cosmology to the case of inflation based on STG. For this purpose it is possible to use the examples of exact solutions for inflation based on the Einstein gravity represented in [34,35]. Also it is of interest to pay attention to a new class of exact inflationary solutions in GR dubbed the constant-roll ones which found in [36] and they compared with observations in [37].

In this paper, we consider the generalized scalar–tensor gravity theory and a deviation during inflationary stage from de Sitter expansion for such theories. This approach allow us to comply with the inflationary paradigm which implies quasi de Sitter expansion at an early stage of the evolution of the universe. Also we obtain the exact solutions of the cosmological dynamic equations and the parameters of cosmological perturbations in the generalized scalar–tensor gravity.

This paper is organized as follows. In Sect. 2 we represent the generalized scalar–tensor (GST) theory which includes

[a] e-mail: ingvor@inbox.ru
[b] e-mail: chervon.sergey@gmail.com